US007558513B2

(12) **United States Patent**
Sugimoto et al.

(10) **Patent No.: US 7,558,513 B2**
(45) **Date of Patent: Jul. 7, 2009**

(54) **DEVELOPING DEVICE AND IMAGE FORMING APPARATUS**

(75) Inventors: **Hiroko Sugimoto**, Osaka (JP); **Hirohisa Endou**, Osaka (JP); **Yukihiro Mori**, Osaka (JP)

(73) Assignee: **Kyocera Mita Corporation** (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 415 days.

(21) Appl. No.: **11/602,076**

(22) Filed: **Nov. 20, 2006**

(65) **Prior Publication Data**

US 2007/0122203 A1 May 31, 2007

(30) **Foreign Application Priority Data**

Nov. 28, 2005 (JP) 2005-342382

(51) **Int. Cl.**
G03G 15/08 (2006.01)
G03G 21/00 (2006.01)

(52) **U.S. Cl.** **399/254**; 399/256; 399/258; 399/359

(58) **Field of Classification Search** 399/265, 399/256, 254, 255, 263, 359, 258
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,723,143	A *	2/1988	Enomoto	399/254
5,355,199	A *	10/1994	Bray	399/256
5,659,859	A *	8/1997	Kikuta et al.	399/256
6,249,664	B1 *	6/2001	Sato	399/256
7,024,151	B2 *	4/2006	Katoh et al.	399/359
7,039,344	B2 *	5/2006	Nishiyama	399/254
7,333,755	B2 *	2/2008	Koido	399/254
2003/0156859	A1 *	8/2003	Tamai	399/254
2005/0111883	A1 *	5/2005	Amano et al.	399/254

FOREIGN PATENT DOCUMENTS

JP	59100472	A *	6/1984
JP	05-249828		9/1993
JP	08-054809		2/1996
JP	09-197786		7/1997
JP	2000-029312		1/2000
JP	2001-235933		8/2001

* cited by examiner

Primary Examiner—Susan S Lee
(74) *Attorney, Agent, or Firm*—Gerald E. Hespos; Anthony J. Casella

(57) **ABSTRACT**

A housing of a developing device has a circulating conveyance passage with a front conveyance passage along a developing roller and a rear conveyance passage parallel to the front conveyance passage. Front and rear spiral feeders are provided in the front and rear conveyance passages for conveying developer particles. The housing has a first developer inlet opening for receiving developer particles from a developer supplier and a second developer inlet opening for receiving recycled developer particles. The rear spiral feeder includes a conveyance power reduction portion at a position downstream from the first and second developer inlet openings and locally reduces conveyance power. The first and second developer inlet openings upstream of the conveyance power reduction portion and are where developer particles are likely to be upwardly surged due to the rotation of the rear conveyer.

12 Claims, 6 Drawing Sheets

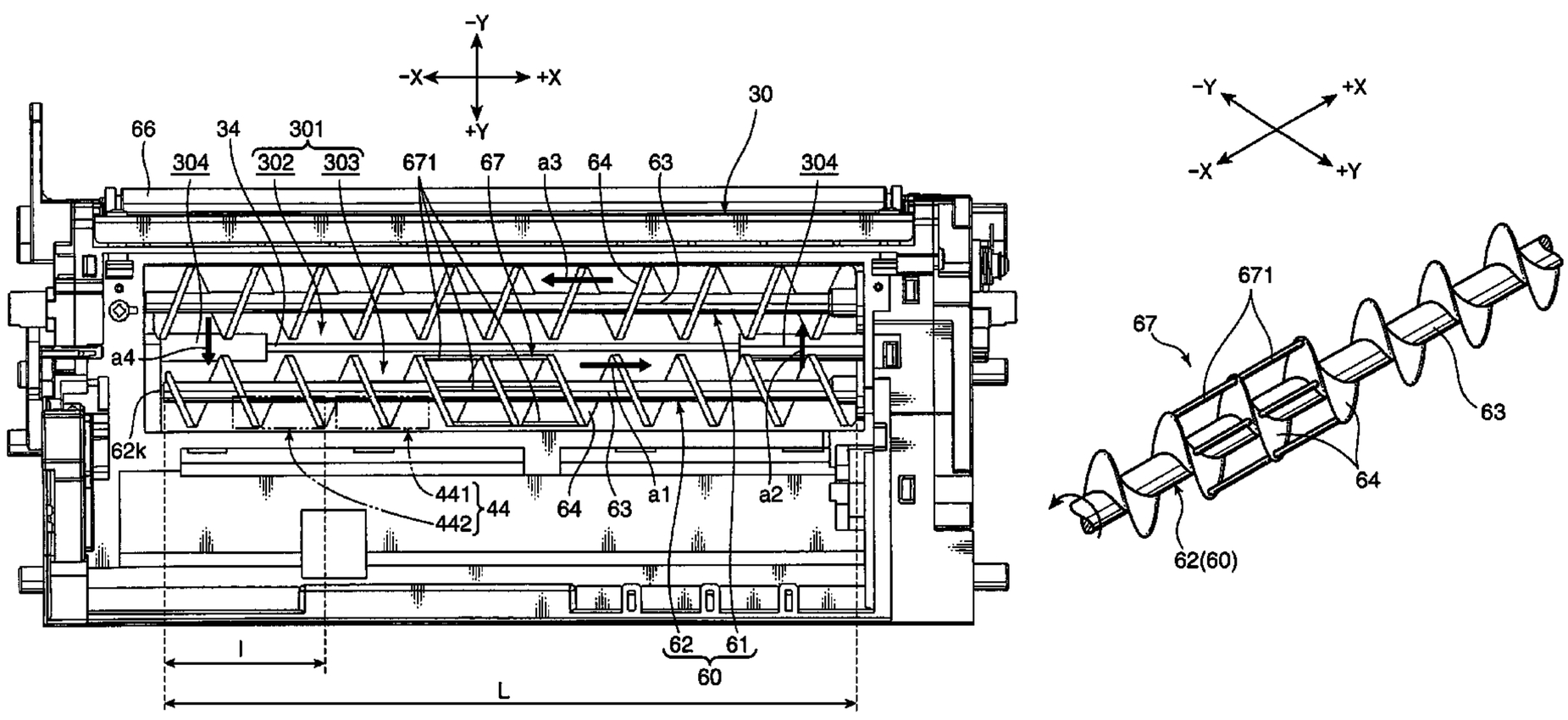


FIG. 1

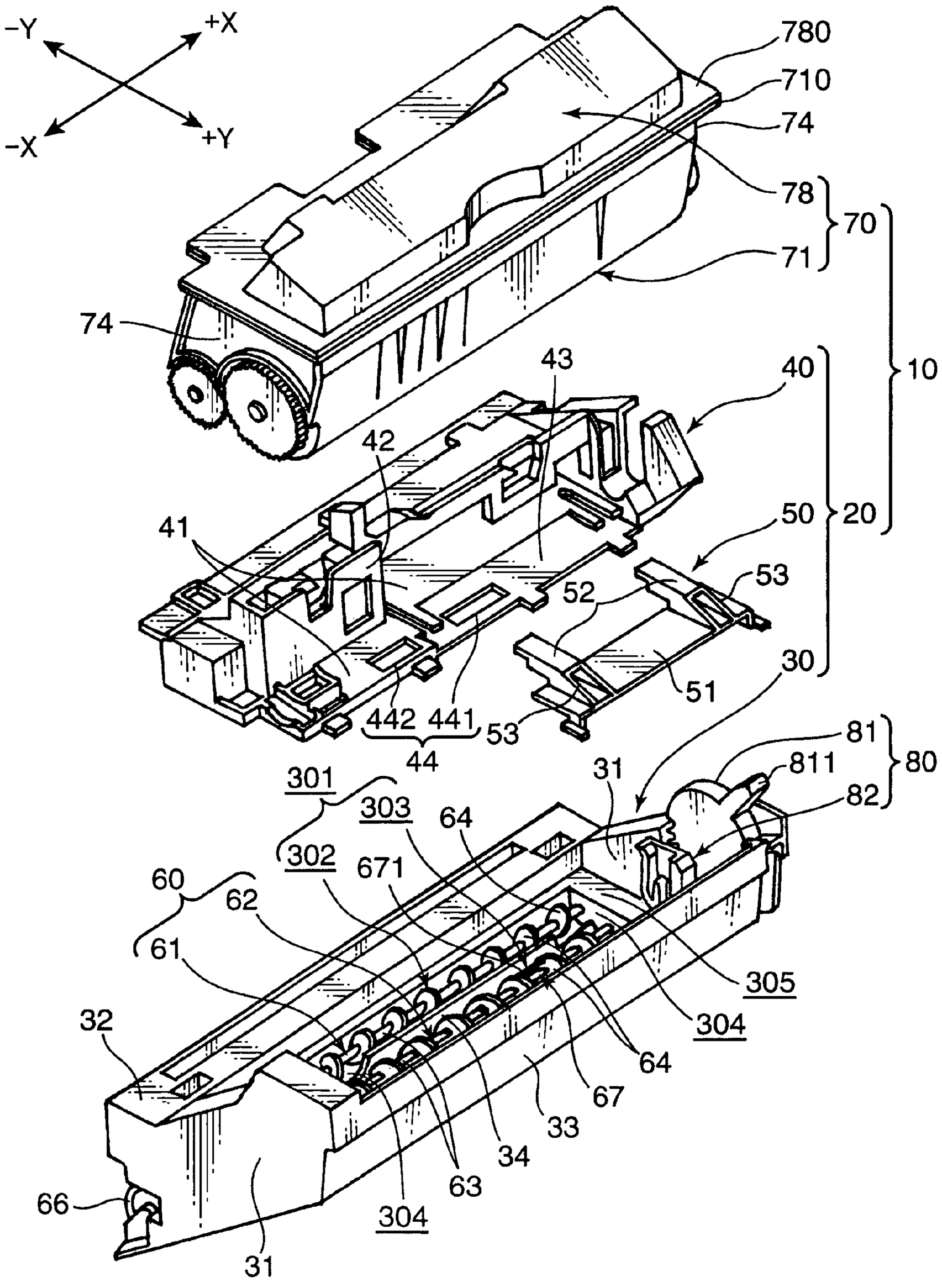

-Y
+X
-X
+Y
780
710
74
78
70
71
74
43
40
10
42
41
50
20
53
52
53
30
51
442 441
53
44
81
811
80
82
301
303
64
31
302
671
60
62
61
305
304
32
64
67
33
34
63
304
66
31

FIG. 2

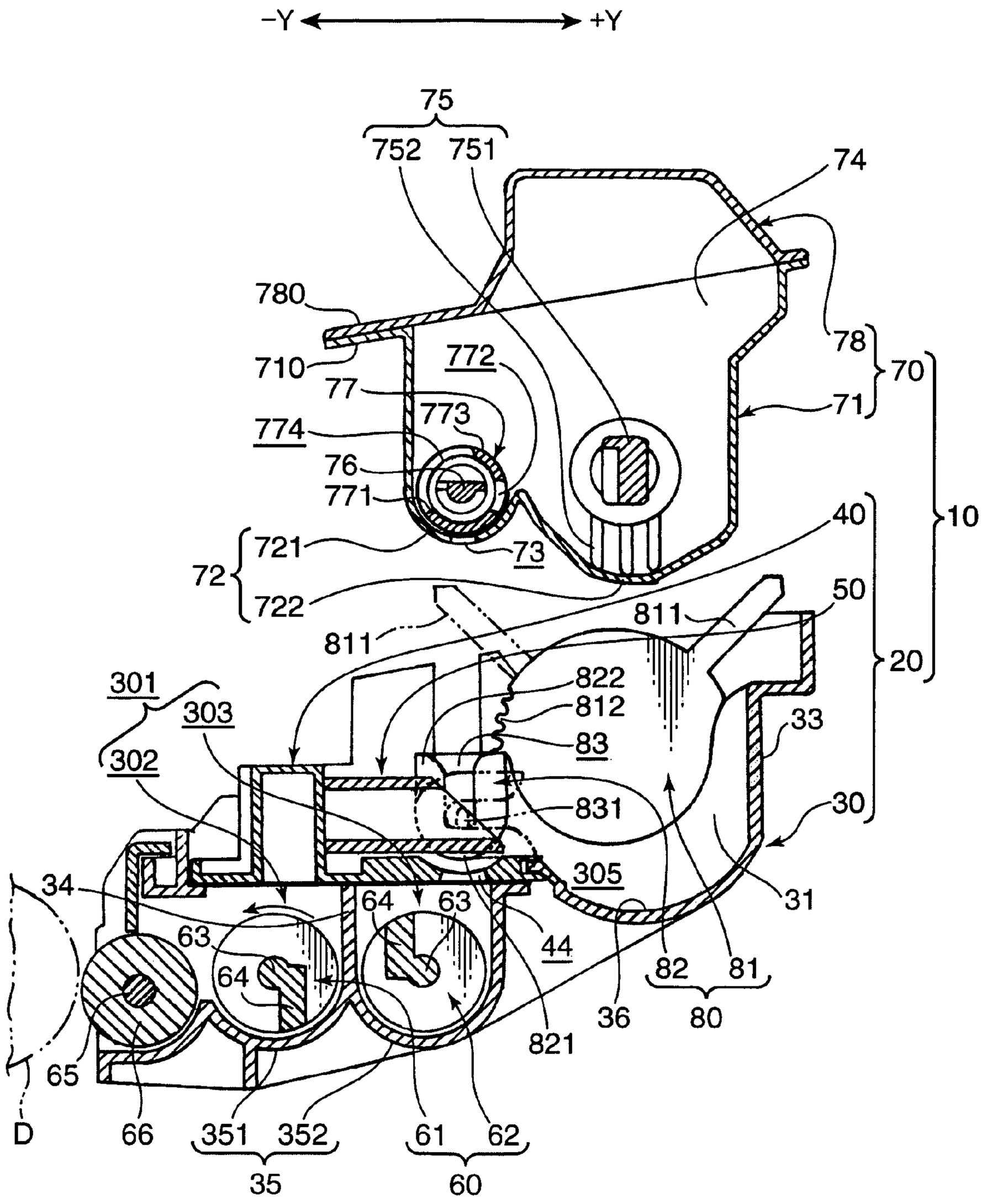
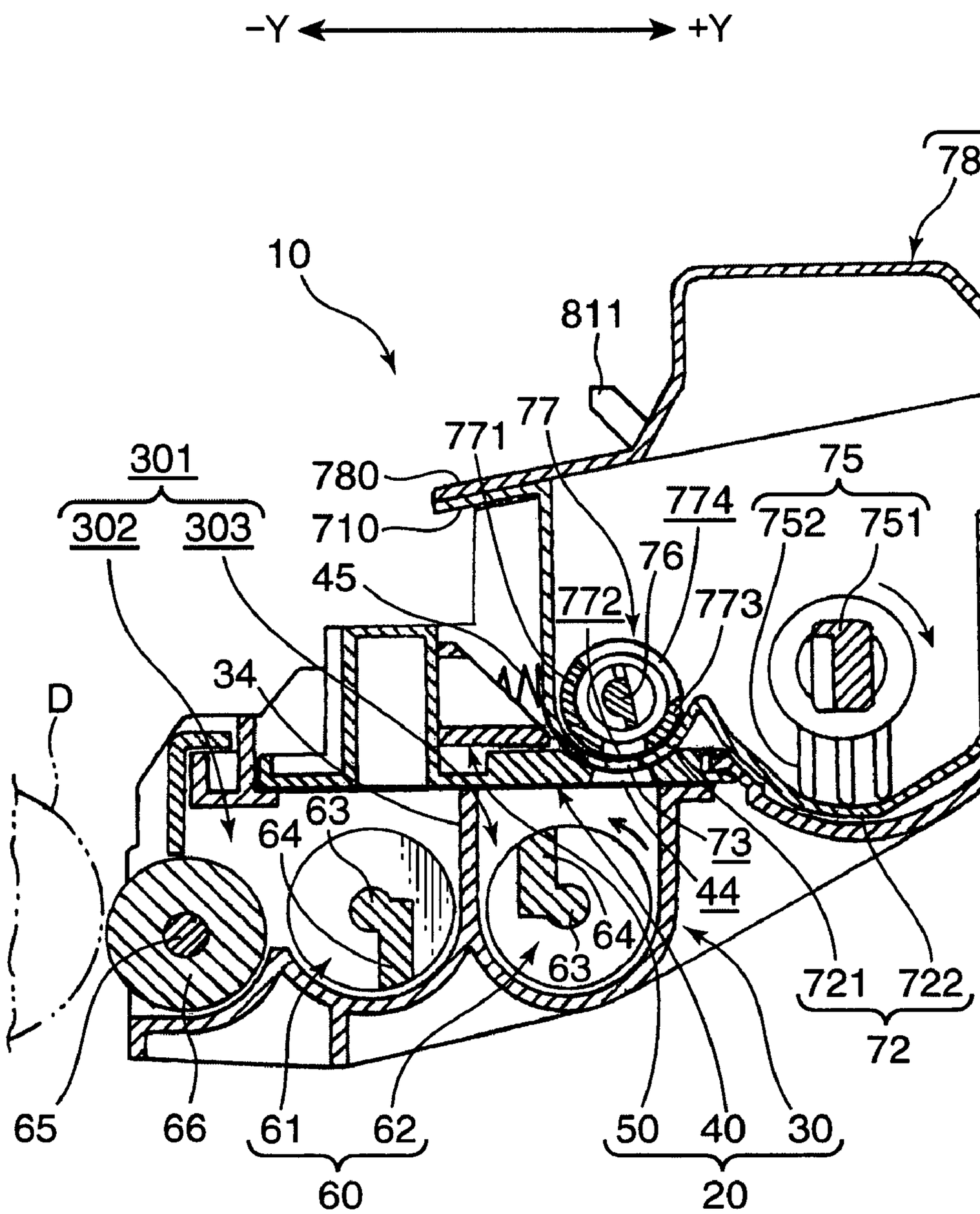

-Y
+Y
75
752
751
74
780
710
772
77
773
774
76
771
78
70
71
10
40
721
72
722
73
50
811
811
822
812
83
33
301
303
302
831
30
305
31
34
64
63
63
64
44
82
81
80
36
821
65
66
351
352
61
62
35
60
D
20

FIG. 3


-Y
+Y
70
78
71
10
811
77
771
301
780
75
302
303
710
774
752
751
45
76
772
773
33
34
D
63
64
73
44
64
63
721
722
72
65
66
61
62
50
40
30
60
20

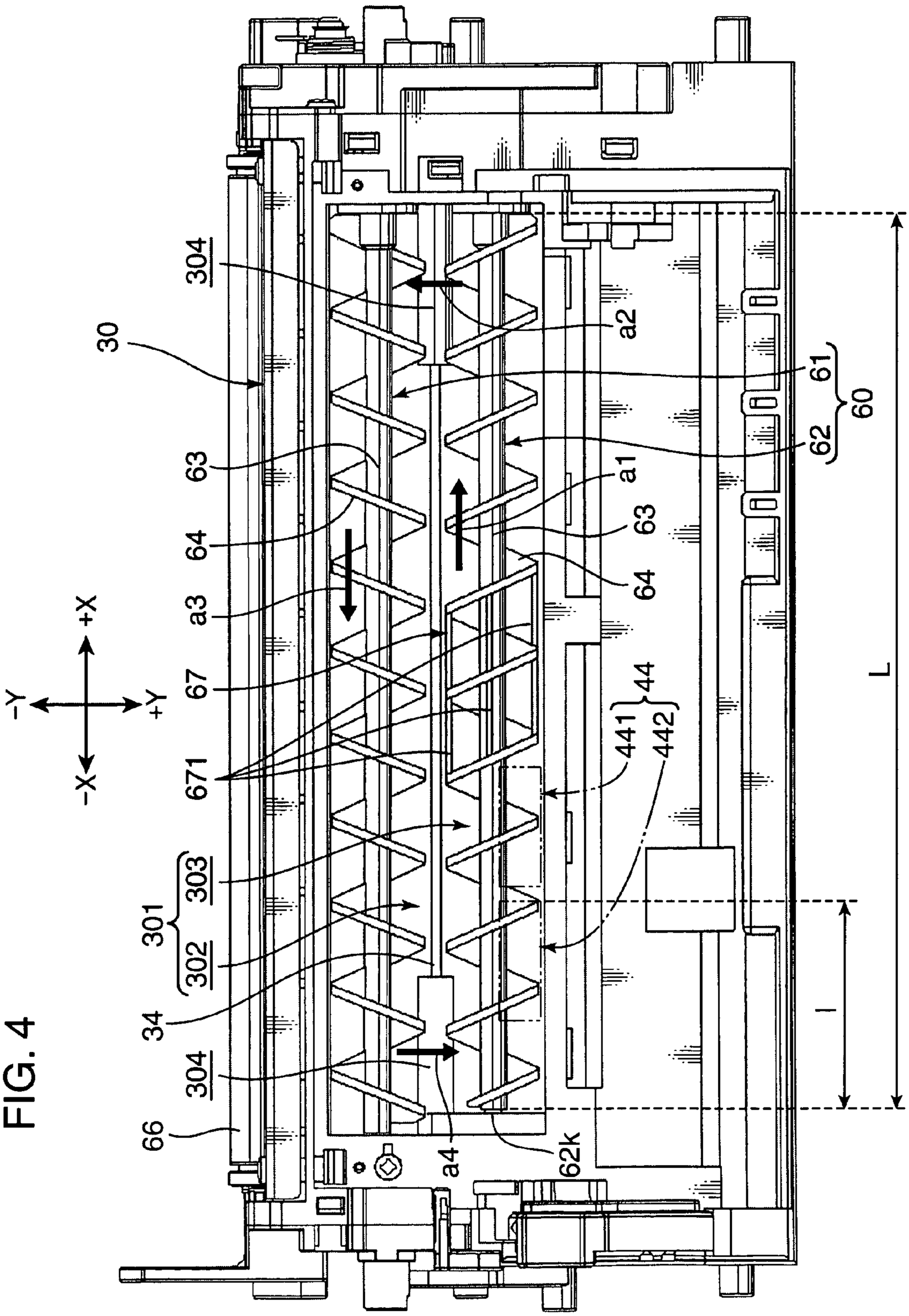

304
30
a2
61
60
62
63
a1
64
a3
67
671
44
441
442
+X
-X
+Y
-Y
L
l
301
303
302
34
304
66
a4
62k

FIG. 4

FIG. 5

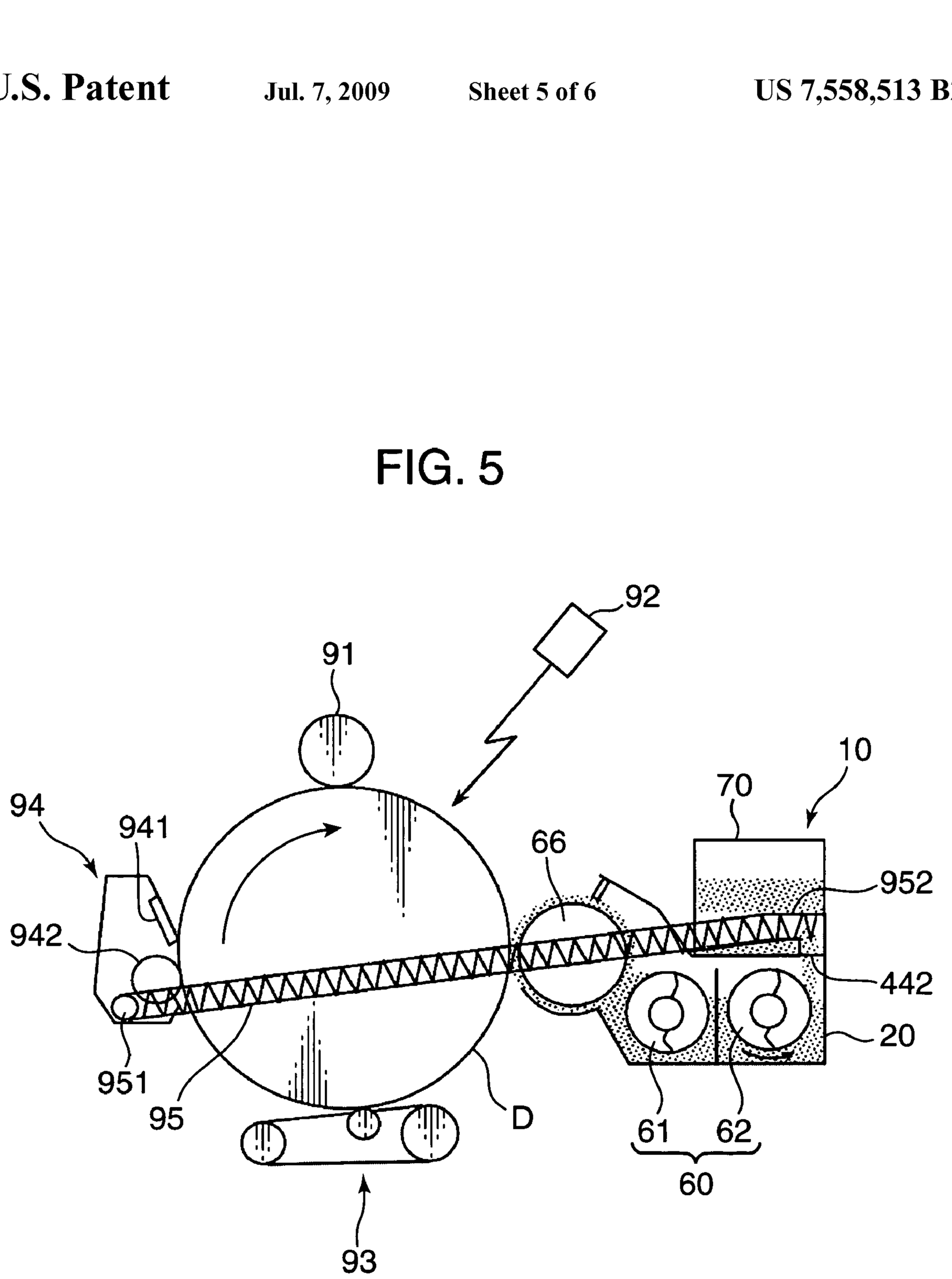
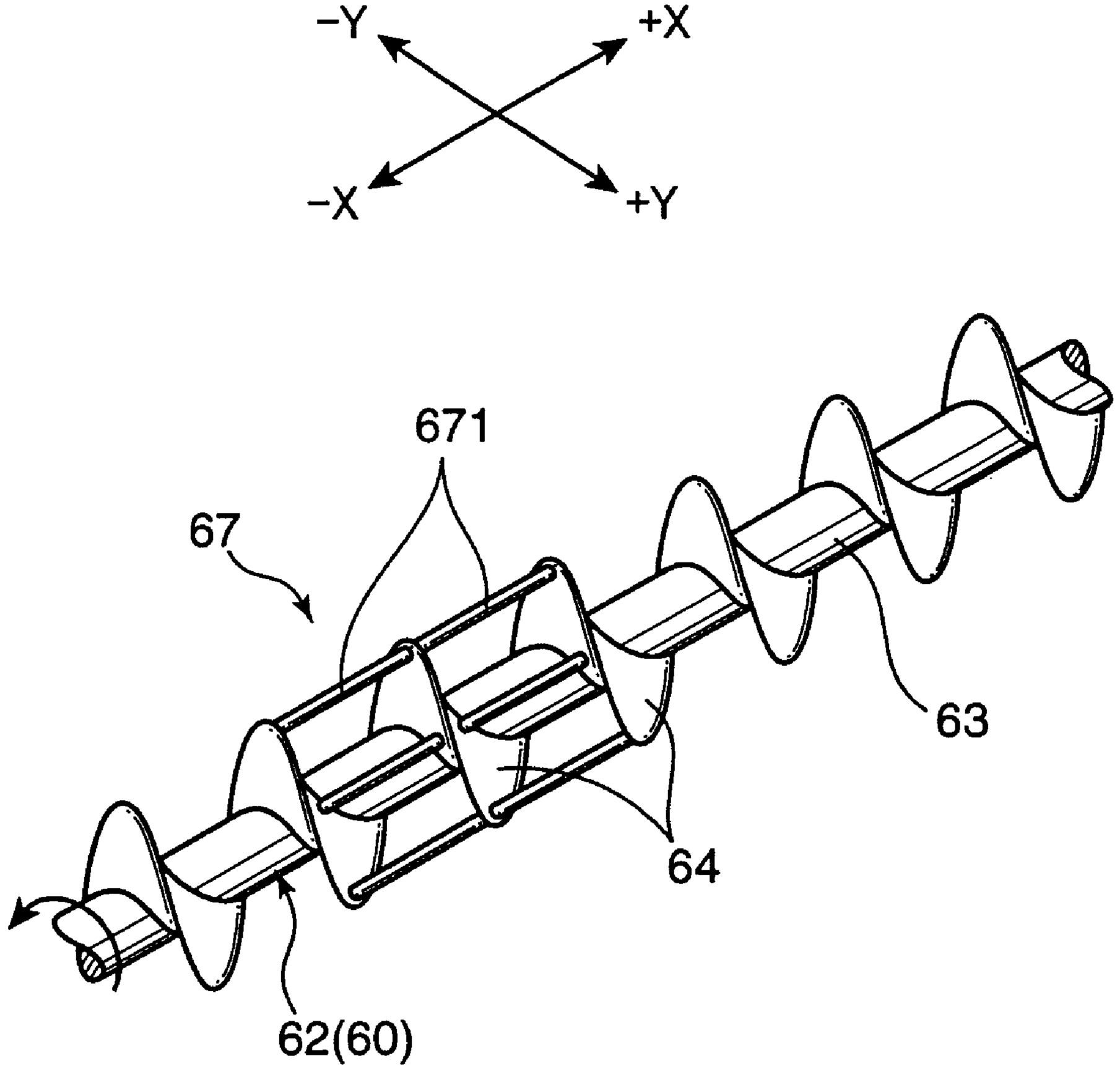


FIG. 6



DEVELOPING DEVICE AND IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a copying machine and a facsimile machine, various kinds of image forming apparatuses such as a printer and a developing device applied to the image forming apparatuses. More particularly, it relates to a developing device and an image forming apparatus including a mechanism for resupplying recycled toner particles.

2. Description of the Related Art

As a developing device applied to image forming apparatuses such as a copying machine and a facsimile machine, a developing device disclosed in a Japanese Unexamined Patent Publication No. 2001-235933 is known. The developing device includes a housing for supplying toner particles to a photoconductive drum of an image forming apparatus, and a toner cartridge detachably mounted on the housing for supplying toner particles. In a bottom portion of the toner cartridge, an openable and closable toner discharging section is formed. In the housing, a toner inlet section corresponding to the toner discharging section is formed. When the toner discharging section is opened by mounting the toner cartridge on the housing, toner particles stored in the toner cartridge is supplied to a predetermined circulating conveyance passage provided in the housing.

The circulating conveyance passage is formed to be a groove extending parallel in an axial direction of the photoconductive drum and having an open end in its upper portion. The circulating conveyance passage has a front conveyance passage extending along a developing roller, and a rear conveyance passage extending parallel to the front conveyance passage and passing a position to receive developer particles from the developer inlet section. In each of the conveyance passages, a spiral feeder having a spiral fin spirally formed on a periphery of the feeder shaft is provided. Toner particles (toner particles and carrier particles in the case of two-component developer particles) are circulated in the front conveyance passage and the rear conveyance passage in accordance with a rotation of the spiral fin about the feeder shaft.

Toner particles received by the rear conveyance passage from the toner cartridge through the toner inlet section are moved to the front conveyance passage by a rotation of the spiral feeder about the feeder shaft and then sent to the front conveyance passage through a communicating passage at a downstream of the rear conveyance passage. Toner particles moved to the front conveyance passage are supplied to a peripheral surface of the developing roller while being conveyed in accordance with a driving of the spiral feeder in a direction opposite to the conveyance direction of the rear conveyance passage. Remainder of toner particles are conveyed back to the rear conveyance passage at a downstream end of the front conveyance passage. In the case of using two-component developer particles, toner particles and carrier particles are stirred and mixed in the rear conveyance passage. Then, a required amount of developer particles (toner particles and carrier particles) are supplied to the peripheral surface of the developing roller in the front conveyance passage. Remainder of developer particles are conveyed back to the rear conveyance passage.

In a developing device of the Japanese Unexamined Patent Publication No. 2001-235933 having such fundamental construction, a conveyance power reduction portion which is so constructed as to reduce a conveyance power locally is provided at a location which is on downstream of the toner inlet

section in a conveyance direction of the spiral feeder provided in the rear conveyance passage. The conveyance power reduction portion is provided for causing retaining of toner particles on upstream thereof. Since the retaining of toner particles occurs between the conveyance power reduction portion and the toner inlet section, retained toner particles block the toner inlet section to thereby restrict supply of toner particles when enough amount of toner particles exist in the developing device. On the contrary, when toner particles in the developing device are consumed and amount of toner particles is reduced, the retained toner particles are also reduced. Accordingly, a space is formed between the portion where toner particles are retained and the toner inlet section so that toner particles fall down from the toner cartridge and supplied into the developing device. When enough amount of toner particles are supplied into the developing device, retaining of toner particles occurs and the toner inlet section is closed so that the supply of toner particles is restricted. As can be seen, the amount of toner particles supplied to the developing device from the toner cartridge is automatically adjusted in accordance with amount of toner particles existing in the developing device.

Meanwhile, there is a known mechanism aimed for reusing toner particles by recovering toner particles resided on a photoconductive drum after a transferring process and resupplying the same to the developing device as recycled toner particles (for example, refer to Japanese Unexamined Patent Publication Nos. 2001-235933, 2000-29312, HEI8-54809, HEI9-197786 and HEI5-249828). Adopting such mechanism provides an advantage that toner particles resided after the transferring process can be utilized effectively.

However, since the conveyance power reduction portion described above is provided so as to retain toner particles and restrict supply of toner particles from the toner cartridge in the developing device described in Japanese Unexamined Patent Publication No. 2001-235933, a problem of clogging (a phenomenon where toner particles are rammed down and clog a toner inlet section so that toner particles are not supplied from the toner cartridge even though toner particles run short) has been arose when the developing device is, for example, in a high-temperature environment or in the condition where a low-darkness printing is executed for a long time so that few toner particles are consumed.

Especially in the case where toner particles resided on the photoconductive drum after a transferring process is recovered and supplied again to the developing device as recycled toner particles, there has been a problem that clogging is likely to occur since a fluidity of recycled toner particles is generally lowered. Further, since recycled toner particles have low charging characteristic, there has been a problem that toner particles are not well mixed (well attached with charges) with carrier particles. This is because recycled toner particles undergo various kinds of stresses before they are resupplied to the developing device and various changes such as separation and burial of agent particles and aggregation of toner particles so that fluidity and charging characteristic are changed from the initial state.

SUMMARY OF THE INVENTION

The invention present invention has worked out in view of the problems described above and is intended for a developing device including a conveyance power reduction portion. An object of the invention is to effectively prevent clogging occurred in a vicinity of a toner inlet section in the toner circulating passage of the developing device. More particularly, an object of the invention is to provide a developing

device and an image forming apparatus capable of preventing the clogging and improving a charging characteristic of toner particles in the case where a mechanism for resupplying recycled toner particles to the developing device is provided.

To achieve the object, the developing device according to the invention has the following construction.

A developing device for supplying developer particles to a peripheral surface of an image bearing member comprises: a housing; a circulating passage for conveying developer particles while stirring them, the circulating passage being provided in the housing; a developer supplier for supplying developer particles in the housing; a developer inlet section for allowing developer particles to come in from the developer supplier, the developer inlet section being formed in an upper portion of the housing; a conveyance mechanism for conveying developer particles received through the developer inlet section, the conveyance mechanism being provided in the circulating passage; and a developing roller provided at a position of facing the image bearing member, wherein: the circulating passage includes a front conveyance passage extending along the developing roller, and a rear conveyance passage extending parallel to the front conveyance passage and passing a position to receive developer particles from the developer inlet section, the conveyance mechanism includes a front conveyer and a rear conveyer which are rotatable about their respective axes to convey developer particles in specified conveyance directions, the front conveyer being provided in the front conveyance passage and the rear conveyer being provided in the rear conveyance passage, the rear conveyer having a conveyance power reduction portion for reducing the conveyance power locally, and the developer inlet section includes a first developer inlet opening for allowing developer particles from the developer supplier to come in, and a second developer inlet opening for allowing developer particles recovered from the image bearing member to come in, the first and second developer inlet openings being provided in the circulating passage at locations which are on upstream of the conveyance power reduction portion of the rear conveyer and where developer particles coming from the first developer inlet opening and/or the second developer inlet opening are likely to be upwardly surged due to the rotation of the rear conveyer.

These and other objects, features, aspects, and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments/examples with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view showing an embodiment of a developing device according to the invention.

FIG. **2** is a sectional view of the developing device shown in FIG. **1** in a side view showing the state where a toner cartridge is detached from a housing of the developing device.

FIG. **3** is a sectional view of the developing device shown in FIG. **1** in a side view showing the state where a toner cartridge is mounted on the housing of the developing device.

FIG. **4** is a sectional plan view of the housing of the developing device.

FIG. **5** is a sectional view showing a system of supplying recycled toner particles.

FIG. **6** is a perspective view showing an embodiment of a conveyance power reduction portion.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is an exploded perspective view showing an embodiment of a developing device according to the invention. FIGS. **2** and **3** are sectional views of the developing device shown in FIG. **1** viewing from side. FIG. **2** shows the state where a toner cartridge is detached from a housing of the developing device, and FIG. **3** shows the state where the toner cartridge is mounted on the housing of the developing device. FIG. **4** is a sectional plan view of the housing of the developing device. In these figures, X-X directions denote width directions, and Y-Y directions denote forward and backward directions. Particularly, −X direction denotes a leftward direction, +X direction denotes a rightward direction, −Y direction denotes a forward direction and +Y direction denotes a backward direction.

As shown in FIG. **1**, a developing device **10** has a fundamental structure including a main body **20** (a housing portion) and a toner cartridge **70** (developer supplier). The main body **20** is provided adjacent to a photoconductive drum (image bearing member) D (refer to FIGS. **2** and **3**) for supplying developer particles to a peripheral surface of the photoconductive drum D. The toner cartridge **70** is detachably mounted on the main body **20** and is adapted for supplying toner particles in the main body **20**. In the embodiment, two-component developer particles including carrier particles and toner particles are used as an example of the developer particles.

The main body **20** includes a housing **30**, a cover body **40** and a cover body shutting member **50**. The housing **30** has a circulating conveyance passage **301** (circulating passage) for circulating two-component developer particles in the main body **20**. The cover body **40** is adapted for closing an opening formed in an upper portion of the housing **30**. The cover body shutting member **50** is attached to the cover body **40** for opening and closing a first toner inlet opening **441** (first developer inlet opening) formed on the cover body **40**. The main body **20** is formed by fixedly placing on the housing **30** the cover body **40** to which the cover shutter member **50** is attached.

The housing **30** includes a pair of side plates **31**, a front plate **32**, a rear plate **33** and a bottom plate **35**. Each side plate **31** is formed to have a shape similar to a rhombus extending downwardly in a frontward direction and is provided in a widthwise part of the housing **30**. The front plate **32** is provided extendingly between front ends of the respective side plates **31**. The rear plate **33** is provided extendingly between rear ends of the side plates **31**. The bottom plate **35** is provided extendingly in lower end parts of the side plates **31** and of the rear plates **33** (FIG. **2**). In a space surrounded by the side plates **31**, the front plate **32**, the rear plate **33** and the bottom plate **35**, a circulating conveyance passage **301** for circulatedly conveying developer particles. A pair of spiral feeders **60** are provided in the circulating conveyance passage **301**. Further, a developing roller **66** is provided in front of the spiral feeders **60**.

The circulating conveyance passage **301** includes a front conveyance passage **302** and a rear conveyance passage **303**. The front conveyance passage **302** is formed in a front portion extendingly along the developing roller **66** and is long in a width direction. The rear conveyance passage **303** is formed behind the front conveyance passage **302** and is formed parallel to the front conveyance passage **302**. The spiral feeder **60**

includes a front spiral feeder **61** (front conveyance mechanism) and a rear spiral feeder **62** (rear conveyance mechanism). The front spiral feeder **61** is provided in the front conveyance passage **302**. The rear spiral feeder **62** is provided in the rear conveyance passage **303**. As shown in FIG. **2**, a front conveyance passage bottom plate **351** and a rear conveyance passage bottom plate **352** are provided in the bottom plate **35** of the circulating conveyance passage **301**. The front conveyance passage bottom plate **351** has an arc-shaped cross section corresponding to the front conveyance passage **302**. The rear conveyance passage bottom plate **352** has an arc-shaped cross section corresponding to the rear conveyance passage **303**. The front spiral feeder **61** and the rear spiral feeder **62** are rotationally driven by an unillustrated driving section such as a driving motor.

Each of the front spiral feeder **61** and the rear spiral feeder **62** has a feeder shaft **63** and a spiral fin **64**. Each feeder shaft **63** is extendingly provided between the pair of side plates **31** in the circulating conveyance passage **301**. The spiral fin **64** is spirally formed around the feeder shaft **63**. The spiral feeders **61**, **62** circulatedly convey developer particles supplied in the circulating conveyance passage **301** by an integral rotation of the spiral fin **64** around the feeder shaft **63**.

In the embodiment, the spiral fin **64** of the front spiral feeder **61** has a counter-clockwise spiral moving forward by a rotation in a counter-clockwise direction viewed from an end of the feeder shaft **63**. On the other hand, the spiral fin **64** of the rear spiral feeder **62** has a clockwise spiral moving forward by a rotation in a clockwise direction viewing from an end of the feeder shaft **63**. Thus, when the front spiral feeder **61** is rotated in a counter-clockwise direction about the feeder shaft **63**, developer particles positioned in the front conveyance passage **302** are moved in a leftward direction (a direction indicated by an arrow a**3** in FIG. **4**). On the other hand, when the rear spiral feeder **62** is rotated in a counter-clockwise direction about the feeder shaft **63**, developer particles in the rear conveyance passage **303** are conveyed in a rightward direction (a direction indicated by an arrow a**1** in FIG. **4**).

Further, a partition wall **34** is provided between the front conveyance passage **302** and the rear conveyance passage **303** so as to divide the conveyance passages **302**, **303**. Further, the partition wall **34** has notches each formed in a left end portion and right end portion thereof providing communication passages **304**, **304** bypassing opposite ends of the front conveyance passage **302** and the rear conveyance passage **303**. Accordingly, a circulating passage for circulating developer particles passing through the front conveyance passage **302**, the rear conveyance passage **303** and communication passages **304**, **304** can be formed. Herein, when the front spiral feeder **61** and the rear spiral feeder **62** are rotated respectively about the feeder shaft **63** in a counter-clockwise direction, the developer particles in the circulating conveyance passage **301** are circulatedly conveyed in a counter clockwise direction between the front conveyance passage **302** and the rear conveyance passage **303** through the communication passages **304**, **304** as indicated by arrows a**1** through a**4** in FIG. **4**.

As shown in FIGS. **2** and **3**, a roller shaft **65** is provided extendingly between the pair of side plates **31** at a front position of the front conveyance passage **302**. Further, a developing roller **66** is axially supported integrally rotatably about the roller shaft **65**. Further, portions where the front conveyance passage **302** and the developing roller **66** are provided is formed to be communicable to each other in almost entire length in a width direction, and a position of the developing roller **66** is set at a position of facing the peripheral surface of the photoconductive drum D located in front. Thus, toner particles included in developer particles to be conveyed in the front conveyance passage **302** are supplied to the peripheral surface of the photoconductive drum D through the developing roller **66**. Accordingly, a toner image is formed on the peripheral surface of the photoconductive drum D.

The cover body **40** includes a plate-like cover main body **41** and a standing wall **42**. The standing wall **42** is positioned at a central position in forward and backward directions of the main body **41** and extends in a width direction. The cover main body **41** has a size set to be slightly larger than an opening formed in an upper portion of the housing **30**. Accordingly, an upper portion of the circulating conveyance passage **301** is closed in the state where the cover main body **41** is covered on the upper face of the housing **30**. In almost widthwisely central part of the cover main body **41** at a backward position from the standing wall **42**, a shutter attaching position **43** for attaching the cover body shutting member **50** is provided.

In the cover main body **41**, a toner inlet section **44** for filling the housing **30** with toner particles is provided. The toner inlet section **44** includes a first toner inlet opening **441** (first developer inlet opening) for allowing toner particles from the toner cartridge **70** to come into the housing **30** and a second toner inlet opening **442** (second developer inlet opening) for allowing recycled toner particles recovered from the photoconductive drum D to come into the housing **30**. The first toner inlet opening **441** and the second toner inlet opening **442** are serially arranged on the circulating conveyance passage **301** (rear conveyance passage **303**) and are provided at locations which are on upstream of a conveyance power reduction portion **67** of the rear spiral feeder **62** described herein after in the circulating passage. Further, the first toner inlet opening **441** is provided in the shutter placing portion **43**, and the cover body shutter member **50** is provided for opening and closing the toner inlet opening **441**.

The toner inlet section **44** (the first toner inlet opening **441** and the second toner inlet opening **442**) is provided at a position where toner particles coming through the first toner inlet section **44** to the housing **30** are likely to be upwardly surged due to a rotation of the rear spiral feeder **62**. In other words, as shown in FIGS. **2** and **3**, the toner inlet section **44** is provided at a position of facing an upstream of the rotational direction of the rear spiral feeder **62** in the state where the cover body **40** is placed on the housing **30**. In the embodiment, the rear spiral feeder **62** is configured to be rotated in a counter clockwise direction about the feeder shaft **63**. Accordingly, the toner inlet section **44** is provided at an upstream of the rotational direction. That is to say, with regard to a rotational direction of the rear spiral feeder **62** in a cross section perpendicular to the feeder shaft **63**, in the case where an upstream of the rotational direction indicates a rotational part which comes close to the toner inlet section **44** within a rotation about the feeder shaft **63** and a downstream of the rotational direction indicates a rotational part which moves away from the toner inlet section **44**, the toner inlet section **44** is provided so as to face the upstream of the rotational direction of the rear spiral feeder **62**.

Thus, toner particles supplied into the rear conveyance passage **303** through the toner inlet section **44** are guided by a rotation of spiral fin **64** of the rear spiral feeder **62** and moved in an upper part of the spiral fin **64** from the rear part to the front part. Thereafter, toner particles are led by the rotation of the spiral fin **64** in the counter-clockwise direction about the feeder shaft **63** and conveyed in a rightward direction (backside of sheets of FIGS. **2** and **3**). At this time, toner particles are stirred and mixed with carrier particles existing in the rear conveyance passage **303**. It will be described

hereinafter, but it should be noted that such manner of supplying toner particles suppresses clogging of toner particles.

Next, a preferable location of the toner inlet section **44** on the circulating conveyance passage **301** (rear conveyance passage **303**) is described. In the invention, the toner inlet section **44** may be positioned at an upstream of the conveyance power reduction portion **67** of the rear spiral feeder **62** in the circulating conveyance passage **301** . However, since the recycled toner particles which generally have lower charging characteristic and fluidity are resupplied, it is preferable to send out the recycled toner particles after providing enough charging characteristic thereto. Accordingly, it is preferable that at least the second toner inlet opening **442** for resupplying recycled toner particles is provided at as much upstream of the rear conveyance passage **303** as possible so that recycled toner particles to be resupplied and carrier particles are well stirred and mixed in the spiral feeder **62**.

Particularly, as shown in FIG. **4**, it is preferable that the second toner inlet opening **442** is provided in a location which satisfies the following equation (1) where l denotes a distance between an upstream end **62***k* of the rear spiral feeder **62** and a downstream end of the second toner inlet opening **442**, and L denotes a length of the rear spiral feeder **62**.

$$\leqq 2/5 \times L \tag{1}$$

Especially, it is preferable to satisfy the following equation (2).

$$l \leqq 1/3 \times L \tag{2}$$

Setting a position of the second toner inlet opening **442** as described above conserves enough time for stirring and mixing recycled toner particles to be resupplied. A frictional charging occurred between recycled toner particles and carrier particles during that time serves enough electrostatic adherence therebetween. Consequently, recycled toner particles can be mixed appropriately with carrier particles.

Such effect becomes apparent if toner particles having an average particle size of 4.0 to 7.5 μm are used and toner-blended agent having more than 2.0 wt % or particularly more than 3.0 wt % of total amount of agent particles are used. Namely, since lowering of fluidity and increase in adherence becomes apparent as particle size of toner particles becomes smaller, some means such as increasing fluidity by increasing amount of agent or lowering adherence by adding large-diameter agent are taken. However, in the case where the fluidity is secured by adding large amount of agent, recycled toner particles are likely to be separated from the agent particles. Accordingly, lowering of the fluidity becomes especially apparent. Further, in the case where a large-diameter agent is used, burial of toner particles occurs, and effect of such phenomenon becomes more apparent when recycled toner particles are used. If the invention is applied in the case where such mixture of toner particles is used and recycled toner particles are re-supplied into the main body **20** of the developing device, especially the fluidity and charging characteristic of recycled toner particles can be improved.

It is preferable that the second toner inlet opening **442** (or first toner inlet opening **441**) is formed on as much upstream in the rear conveyance passage **303** as possible. However, it is preferable that a portion of the communication passage **304** and the second toner inlet opening **442** does not completely overlap with each other. In the communication passage **304**, developer particles are conveyed in a direction indicated by the arrow a**4** from the front conveyance passage **302**. On the other hand, a flow of the developer particles is so complicated due to a rotational driving force the rear spiral feeder **62**. Accordingly, supplied recycled toner particles (new toner particles) are not well mixed with carrier particles. For example, in the case where a rotational direction of the rear spiral feeder **62** is the same as that of the direction indicated by arrow a**4** from upper view, great amount of developer particles are pressingly compressed toward a side wall of the developing device **20** facing the communication passage **304**. Accordingly, supplied toner particles are susceptible to be retained therein. Further, also in the case where the rotational direction of the rear spiral feeder **62** is reversed with respect to the direction indicated by the arrow a**4**, movement of toner particles toward the direction which the toner particles are conveyed is balanced out by developer particles conveyed from the communication passage **304** toward the direction indicated by the arrow a**4**. Accordingly, a flow of toner particles is disturbed, and toner particles are likely to be retained therein. Consequently, it is preferable that the second toner inlet opening **442** (or the first toner inlet opening **441**) is positioned on a slightly downstream of the conveyance direction from the communication passage **304**.

However, it is preferable that the second toner inlet opening **442** (or the first toner inlet opening **441**) is not completely separated from the communication passage **304** but is placed close to the communication passage **304** to some extent. A flow of developer particles becomes more stable if the second toner inlet opening **442** is placed away toward the downstream and roughness in surfaces (upper surface of a particle flow layer) of developer particles is calm. However, if the flow of developer particles is stable, electrostatic adherence by a frictional charging with carrier particles is not likely to occur since recycled toner particles has low charging characteristic and fluidity. Accordingly, toner particles become less susceptible to be mixed with carrier particles. On the contrary, surface (upper surface of the particle flow layer) of developer particles is rough in proximity of the communication passage **304**. Accordingly, it can be expected that recycled toner particles are mingled with carrier particles and likely to be mixed therein.

In the embodiment, the second toner inlet opening **442** for supplying recycled toner particles is positioned on an upstream in a conveyance direction from the first toner inlet section **441** for supplying new toner particles. Positioning the inlet openings in such a manner reserves time long enough for stirring and mixing recycled toner particles having low charging characteristics and fluidity. Of course, the first toner inlet opening **441** may be formed on an upstream in a conveyance direction from the second toner inlet opening **442**. Further, it should be noted that the first toner inlet opening **441** does not necessarily have to be formed at a position satisfying the equations (1) and (2) described above. However, it is preferable that the first inlet opening **441** at a position satisfying the equations (1) and (2) described above to reserve enough time for stirring and mixing new toner particles supplied from the first toner inlet opening **441**, resided developer particles and recycled toner particles.

The cover body shutting member **50** includes a shutter plate **51** and a pair of projections **52**. The shutter plate **51** corresponds to the first toner inlet opening **441**. The pair of projections **52** are provided in opposite widthwise ends of the shutter plate **51** and extend in forward and backward directions thereof. The shutter plate **51** has a enough size for closing up the first toner inlet opening **441**. Further, at each rear end of the pair of projections **52**, a sloped surface **53** having an end sloping downward in a backward direction is provided. These sloped surfaces **53** are adapted for moving the cover shutter member **50** when the toner cartridge **70** is mounted on the main body **20** of the developing device and comes in contact with the bottom portion of the toner car-

tridge **70**. The shutter plate **51** moves forward by the sloped surfaces **53** so that the first toner inlet opening **441** becomes open.

As shown in FIG. **3**, in the state where the toner cartridge **70** is mounted on the main body **20** of the developing device, the toner cartridge **70** is pressed backward by a coil spring **45** which is a biasing member. Accordingly, the mounting state of the toner cartridge **70** against the main body **20** of the developing device becomes stable.

The cover body shutting member **50** is urged to move backward by an unillustrated biasing member such as a coil spring. Thus, in the state where the toner cartridge **70** is not mounted on the main body **20** of developing device, the first toner inlet opening **441** falls in the state of being closed by the shutter plate **51**. On the other hand, when the toner cartridge **70** is mounted on the main body **20** of the developing device, the sloped surface **53** of the cover shutter member **50** is pressed by a lower portion of the toner cartridge **70** so as to move forward while resisting against the biasing force generated by the biasing member. Accordingly, the first toner inlet opening **441** becomes open.

As shown in FIG. **1**, the toner cartridge **70** includes a cartridge main body **71** for storing toner particles and a cover body **78** for closing an upper opening of the cartridge main body **71**. At an upper end portion of the cartridge main body **71**, an annular main body flange portion **710** projecting outward is provided. On the other hand, the cover body **78** has a cover flange portion **780** corresponding to the main body flange portion **710**. In the state where the toner cartridge **70** is filled with toner particles, the flange portions **710**, **780** are fixed with each other by an adhesion process and the like. Consequently, the toner cartridge **70** filled with toner particles therein is finalized.

The cartridge main body **71** has a leftward and rightward width set to be slightly smaller than the distance between the pair of side plates in the housing of the main body **20** of the developing device. A forward and backward size of the cartridge main body **71** is set to be slightly smaller than an inner size between the rear plate **33** of the housing **30** and the standing wall **42** of the cover body **40**. Accordingly, the toner cartridge **70** is placed on upper part of the circulating conveyance passage **301** of the housing **30** and is detachably placed on the cartridge mounting space **305** surrounded by the side plates **31**, the rear plate **33** and the standing wall **42**.

As shown in FIG. **2**, the cartridge main body **71** is formed to have the bottom plate **72** having two bumps in a side view. Namely, the bottom plate **72** has a front arc-shaped bottom plate **721** corresponding to the shutter placing portion **43** of the cover body **40** and a rear arc-shaped bottom plate **72** formed on a backward position of the front arc-shaped bottom plate **721**.

In the bottommost position of the front arc-shaped bottom plate **721**, a toner discharging opening **73** is formed at a position of facing the toner inlet section **44** (first toner inlet opening **441**) of the cover body **40**. In the state where the toner cartridge **70** is mounted on the housing **30** (FIG. **3**), toner particles stored in the toner cartridge **70** are supplied to the housing **30** through the toner discharging portion **73** and the toner inlet section **44** of the cover body **40**.

In an upper portion of the rear arc-shaped bottom plate **722**, a stirring member **75** is extendingly provided between the pair of side plates **74** along a curvature center position of the rear arc-shaped bottom plate **722**. The stirring member **75** includes a shaft member **751** and a stirring fin **752**. The shaft member **751** extends between the pair of side plates **74** rotatably about its axis center. The stirring fin **752** projects from a peripheral surface of the shaft member **751** in a radial direction. The stirring fin **752** is formed of a sheet body made of synthetic resin, and the stirring member **75** is rotated by driving of an unillustrated driving motor in a clockwise direction in FIG. **3** about the axis center. Accordingly, toner particles on the rear arc-shaped bottom plate **722** are scraped off and supplied to the front arc-shaped bottom plate **721**.

In an upper portion of the front arc-shaped bottom plate **721**, a spiral rod **76** extendingly provided between the pair of side plates **74** along a curvature center position of the front arc-shaped bottom plate **721** and a cartridge side shutter member **77** exteriorly placed on the spiral rod **76**. A setting of direction and a rotational direction of the spiral rod **76** is set so that the spiral rod **76** is integrally rotated with the stirring member **75** to thereby convey toner particles sent from the rear arc-shaped bottom plate **722** to the front arc-shaped bottom plate **721** toward the toner discharging portion **73**.

The cartridge shutter member **77** is formed of a cylindrical body rotatably placed on the spiral rod **76** and includes an arc-shaped shutter portion **771**, a elongate hole **772** and an arc-shaped wall **773**. The arc-shaped shutter portion **771** is adapted for closing the toner discharging portion **73**. The elongate hole **772** has a length which is long in a width direction (a direction perpendicular to a sheet of FIG. **2**) and corresponds to the toner discharging portion **73** provided adjacent to a counter-clockwise end portion of the arc-shaped shutter portion **771**. The arc-shaped wall **773** is provided adjacent to the elongate hole **772** in a counter-clockwise direction. Between end portions of the arc-shaped shutter portion **771** and the arc-shaped wall **773** facing each other in a peripheral direction, an opening **774** for supplying toner particles sent by the stirring member **75** to the spiral rod **76**.

The cartridge shutter member **77** is shiftable to a toner discharging portion closing posture shown in FIG. **2** and to a toner discharging portion opening posture shown in FIG. **3**. Further, the side plate **31** on a right side of the housing **30** is provided with a posture shifting operation member **80** for shifting a posture of the cartridge shutter member **77**.

As shown in FIG. **2**, the posture shifting operation member **80** has an operational circular plate **81** and a posture shifting member **82**. The operational circular plate **81** is mounted on outer side of the side plate **31** rotatably about the approximate curvature center of the arc-shaped bottom plate **36** in the cartridge mounting space **305**. The posture shifting member **82** is linked with a rotation of the operational circular plate **81** and shifts the cartridge side shutter member **77** between the toner discharging portion closing posture and the toner discharging portion opening posture. The operational circular plate **81** is provided with an operational lever projecting outwardly in a radial direction of its peripheral surface and engaging teeth **812** on a peripheral surface facing the operational lever **811**.

The posture shifting member **82** consists of a semi-circular portion **821** and a rectangular portion **822**. The semi-circular portion **821** is a semi-circular shaped portion formed in a lower portion of the posture shifting member **82**. The rectangular portion **822** is a rectangular-shaped portion formed integrally in an upper portion of the semi-circular portion **821**. The posture shifting member **82** is mounted in an inner side of the right-hand side plate **31** of the housing **30** and is supported axially and rotatably about an unillustrated shaft so as to have a common curvature center position with that of the semi-circular portion **821**.

In an inner side of the posture shifting member **82**, a fitting groove **83** is formed. The fitting groove **83** is formed convexly toward a curvature center position of the semi-circular portion **821** from an end portion of the rectangular portion **822** at a position of facing the semi-circular portion **821**. A right-

hand end portion of the spiral rod **76** is fitted into the fitting groove **83**. At the curvature center position of the fitting groove **83**, an engaging projection **831** projecting outwardly from a curvature center is formed. On the other hand, at a right-hand end portion of the cartridge shutter member **77**, an unillustrated engaging groove exteriorly placed on the engaging protrusion **831** is provided.

Further, in the state where the operational lever **811** is reclined backward as indicated by a solid line in FIG. **2**, the toner cartridge **70** in the state where the cartridge side shutter member **77** is set in the toner discharging portion closing posture is mounted in the cartridge mounting space **305** of the housing **30**. Accordingly, the engaging groove is exteriorly placed on the engaging projection **831**.

If the operational lever **811** is operated to rotate the operational circular plate **81** in a counter clockwise direction in this state (refer to the operational lever **811** shown in FIG. **2** by a two-dotted chain line), the rotation is transmitted to the posture shifting member **82** through the engaging teeth **812**. Then, the posture shifting member **82** is rotated in a clockwise direction about the curvature center and shifted to a lying posture as indicated by a two-dotted chain line as in FIG. **2**. In accordance with the rotation of the cartridge side shutter member **77** in a clockwise direction through the engaging projection **831**, the cartridge side shutter member **77** is shifted to the toner discharging portion opening posture where the elongate hole **772** faces the toner discharging opening **73**.

The main body **20** of the developing device according to the embodiment also has a system for supplying recycled toner particles in addition to a system for supplying toner particles from the toner cartridge **70** (new toner particles). FIG. **5** is a sectional view showing the system for supplying recycled toner particles and shows a schematic view of an image forming portion around the photoconductive drum D. The image forming portion includes the photoconductive drum D, a charging roller **91**, an exposing device **92**, the above-described developing device **10**, a transferring section **93** and a cleaning section **94**. The photoconductive drum D is an image bearing member consists of, for example, amorphous silicon and is so constructed as to be rotatable in a direction indicated by an arrow in FIG. **5**.

The charging roller **91** is adapted for uniformly charging a surface of the photoconductive drum D at a predetermined electric potential. The exposing device **92** is constructed by a laser scanning unit and the like and is adapted for irradiating a laser beam (LED light ray) to the surface of the photoconductive drum D to form an electrostatic latent image on the photoconductive drum D. The laser beam is formed based on an image data transmitted from an unillustrated image data storing section and the like. The developing device **10** makes toner particles attached to an electrostatic latent image formed on the photoconductive drum D to expose an electrostatic latent image as a toner image. The transferring section **93** transfers toner image on the photoconductive drum D to a recording sheet (unillustrated). The cleaning section **94** is adapted for cleaning toner particles resided on the surface of the photoconductive drum D after a toner transfer by the transferring section **93** is completed. The cleaning section **94** includes a cleaning blade **941** and a cleaning roller **942**. The cleaning blade **941** is adapted for scraping off resided toner particles from the surface of photoconductive drum D.

In such construction, a toner conveyance duct **95** is provided extendingly between the cleaning section **94** and the developing device main body **20**. In the toner conveyance duct **95**, a powder conveyance member such as a spiral feeder is interiorly provided so that powder can be conveyed from one end **951** to the other end **952**. The end **951** of the toner conveyance duct **95** is open in the cleaning section **94**, and the other end **952** is connected to the second toner inlet opening **442** formed in the main body **20**. Thus, when the powder conveyance section is driven, toner particles recovered from the cleaning section **94** (recycled toner particles) are conveyed toward the main body **20** and supplied to the circulating conveyance passage **301** through the second toner inlet opening **442**.

In addition to the above construction, in the main body **20** of the developing device according to the embodiment, as shown in FIG. **4**, the rear spiral feeder **62** is provided with the conveyance power reduction portion **67** at a downstream of the toner inlet section **44** in a conveyance direction. FIG. **6** is a perspective view showing an embodiment of the conveyance power reduction portion **67**. As shown in FIG. **6**, the conveyance power reduction portion **67** includes multiples of reduction rods (rib member) **671** which are provided in a peripheral rim of the spiral fin **64** parallel to the feeder shaft **63** in a peripheral direction. In the embodiment, four reduction rods **671** are provided in an even pitch in a peripheral direction. However, number of reduction rods **671** is not limited to four but can be less or more than four.

Since such conveyance power reduction portion **67** is provided on the rear spiral feeder **67** at a downstream of the toner inlet section **44**, developer particles conveyed to a downstream by the spiral fin **64** rotated by a counter-clockwise rotation of the feeder shaft **63** about the axis center are disturbed by the reduction rod **671** at the time when they reach the conveyance power reduction portion **67** and become difficult to move forward. Accordingly, the developer particles are retained at an upstream of the conveyance power reduction portion **67**. Thus, when toner particles are supplied and amount of developer particles increases, retained developer particles close up the toner inlet section **44** to thereby suppress further supply of toner particles. When toner particles are consumed and amount of accumulated developer particles decreases, a gap is formed between a part where developer particles are retained and the toner inlet section **44**, and toner particles are supplied to the gap.

Hereinafter, operation of the developing device **10** is described. New toner particles are supplied to the main body **20** of the developing device from the toner cartridge **70** through the toner inlet opening **441**, or, recycled toner particles collected in the cleaning section **94** are supplied into the developing device main body **20** through the second toner inlet opening **442**. The first toner inlet opening **441** and the second toner inlet opening **442** are provided above the circulating conveyance passage **301** (rear conveyance passage **303**) and upstream in a conveyance direction from the conveyance power reduction portion **67** provided in the rear spiral feeder **62**. Accordingly, by the above-described retaining of toner particles, new toner particles and recycled toner particles are appropriately supplied in accordance with consumption of toner particles.

Supplied toner particles are stirred and mixed with developer particles (carrier) existing in the main body **20** by the rear spiral feeder **62** and conveyed to a downstream of the rear conveyance passage **303** (a direction indicated by an arrow a**1** in FIG. **4**). Then, the developer particles reach the front conveyance passage **302** through the communication passage **304** as indicated by the arrow a**2**. While the developer particles are conveyed by the front spiral feeder **61** in a direction indicated by the arrow a**3**, a required amount of developer particles are sent out to the developing roller **66**. Thereafter, developer particles including resided toner particles are sent

back to an upstream end of the rear conveyance passage **303** through the communication passage **304** as indicated by an arrow a**4**.

Further, as shown in FIG. **3**, in the developing device **10**, toner inlet section **44** is provided so as to face an upstream of a rotational direction of the spiral feeder **62** in the case where a rotational portion of a rotation in a cross-section perpendicular to the feeder shaft **63** of the rear spiral feeder **62** of the feeder shaft **63** coming close to the toner inlet section **44** (the first toner inlet opening **441** and the second toner inlet opening **442**) is determined as an upstream of a rotational direction and a rotating portion moving away from the toner inlet section **44** is determined as a downstream of the rotational direction. Accordingly, new toner particles supplied from the first toner inlet opening **441** and recycled toner particles supplied from the second toner inlet opening **442** are likely to be upwardly surged by the spiral fin **64** of the rear spiral feeder **62**.

Thus, even if the conveyance of toner particles (developer particles) becomes likely to be retained by conveyance power reduction portion **67** of the rear spiral feeder **62**, a movement of developer particles becomes very active due to an upward surging in a vicinity of the toner inlet section **44**. Further, since toner particles are conveyed in an axial direction through an upstream wall (rear plate **33**), shelf-lifting is not likely to be occurred. Further, since recycled toner particles having less fluidity and charging characteristic may be sufficiently stirred and mixed with the existing developer particles (carrier), an appropriate charging characteristic can be provided. According to these operations, toner particles can be constantly and stably supplied into the main body **20** of the developing device. Further, darkness of toner particles can be stabilized at the time of image forming.

For comparison, in the case where the toner inlet section **44** is formed at a downstream of a rotational direction of the rear spiral feeder **62** (prior art), there is less movement of retained developer particles. Accordingly, developer particles are rammed down. Therefore, in the case where recycled toner particles having less fluidity is resupplied into the developing device main body **20** or in the case where toner particles are in a high-temperature environment where a fluidity of toner particle gets worse and a low darkness printing consuming far less toner particles is performed for a long time, the clogging becomes like to be occurred.

The present invention is not limited to the above-described embodiment but can take embodiments (1) through (3) as described herebelow.

(1) In the above-described embodiment, the spiral fin **64** having a counterclockwise spiral direction is applied as the front spiral feeder **61**, and, on the other hand, the spiral fin **64** having a clockwise spiral direction is adapted as the rear spiral feeder **62**. Accordingly, by rotating the front and rear spiral feeders **61**, **62** in the same direction, toner particles are circulatedly conveyed along the circulating conveyance passage **301**. In place of this, the spiral fins **64** of the front and rear spiral feeders **61**, **62** may have the same spiral direction and be rotated in directions reverse to each other. With such construction, toner particles can be circulatedly conveyed in the circulating conveyance passage **301**.

(2) In the above-described embodiment, the toner inlet section **44** is provided at a downstream of the rear conveyance passage **303** since the rotational direction of the rear spiral feeder **62** is a counter-clockwise direction in FIG. **3**. However, the invention is not limited to provide the toner inlet section at a rear part of the rear conveyance passage **303**. In the case where the rotational direction of the rear spiral feeder **62** is a clockwise direction, the toner inlet section **44** may be provided in a front side of the rear conveyance passage **303**. With such construction, the toner inlet section **44** may be provided in an upstream of the rotational direction of the rear spiral feeder **62**.

(3) In the embodiment, the conveyance power reduction portion **67** is formed by providing the reduction rod **671** parallel to the feeder shaft **63** at a peripheral end portion of the spiral fin **64**. However, the present invention is not limited to form the conveyance power reduction portion **67** by providing the reduction rod **671** on the spiral fin **64** but may adapt various methods as long as it obstructs conveyance of the toner particles. For example, a method of making a radial size of the spiral fin **64** smaller at the part corresponding to the conveyance power reduction portion **67** may be adapted.

Further, the above-described embodiment includes the invention having the following constructions.

The developing device according to one aspect of the invention comprises: a housing for supplying developer particles to a peripheral surface of an image bearing member while stirring the developer particles and conveying the same in the circulating passage; and a developer supplier for supplying developer particles in the housing. The housing includes: a developer inlet section provided in an upper part of the housing; a conveyance mechanism for conveying developer particles received through the developer inlet section, the conveyance mechanism being provided in the circulating passage; and a developing roller provided at a position of facing the image bearing member. The circulating passage includes a front conveyance passage extending along the developing roller, and a rear conveyance passage extending parallel to the front conveyance passage and passing a position to receive developer particles from the developer inlet section. The conveyance mechanism includes a front conveyer and a rear conveyer which are rotatable about their respective axes to convey developer particles in specified conveyance directions. The front conveyer is provided in the rear conveyance passage, and the rear conveyer is provided in the rear conveyance passage. The rear conveyer has a conveyance power reduction portion for reducing the conveyance power locally. The developer inlet section includes: a first developer inlet opening for allowing developer particles from the developer supplier to come in; and a second developer inlet opening for allowing developer particles recovered from the image bearing member to come in. The first and second developer inlet openings are provided in the circulating passage at locations which are on upstream of the conveyance power reduction portion of the rear conveyer. Further, the developer inlet openings are provided at locations where developer particles coming from the first developer opening and the second developer opening are likely to be upwardly surged due to the rotation of the rear conveyer.

Further, an image forming apparatus according to another aspect of the invention comprises: a developing device including a conveyance mechanism for conveying developer particles; and a driving mechanism for driving the conveyance mechanism. The developing device has the construction described above.

According to this construction, both developer particles came into the housing of the developing device from the first developer inlet opening of housing of the developing device from developer supplier and recycled developer particles recovered from the image bearing member came into the housing of the developing device through the second developer inlet opening are upwardly surged by the rotation of the rear conveyer and constantly conveyed in an axial direction at an immediately under the first and second developer inlet openings. Accordingly, the disadvantage of clogging does not

occur. Further, the first and the second developer inlet openings are provided in the circulating passage at locations which are on upstream of the conveyance power reduction portion of the rear conveyer so that developer particles and recycled developer particles are once accumulated in the conveyance passage. Accordingly, in the case where two-component developer is used, a time for frictionally charging toners and carriers can be conserved. Consequently, a charging characteristic of toner particles can be improved.

According to such developing device or image forming apparatus, the clogging does not occur even in the case where recycled developer particles are resupplied into the developing device. Further, the charging characteristic can be improved. Thus, toner particles can be constantly and stably supplied into the developing device, and darkness of toner particles can be stabilized at the time of image forming.

In the above-described construction, it is preferable that the second developer inlet opening is provided in a location which satisfies the equation $l \leqq \frac{2}{5} \times L$ where l denotes a distance between an upstream end of the rear conveyer in a conveyance direction and a downstream end of the second developer inlet opening, and L denotes a length of the rear conveyer.

According to this construction, recycled developer particles come into the casing at a position near to upstream of the conveyance direction of the rear conveyer. Accordingly, in the case where two-component developer particles are used, relatively long time for conveying recycled developer particles (recycled toner particles) having less charging characteristic can be conserved. Accordingly, the charging characteristic can be improved. Further, even if the fluidity of recycled toner particles is lowered, recycled developer particles can be well mixed with respect to carrier particles since the time for stirring by the rear conveyer becomes relatively long. Thus, even in the case of using recycled toner particles, toner particles can be supplied constantly and stably with respect to the developing roller.

Further, in the above-described construction, it is preferable that the second developer inlet opening is provided on upstream of the first developer inlet opening in the circulating passage. According to this construction, recycled developer particles having lower charging characteristic is supplied from a position upstream from the position where new developer particles supplied from the developer supplier. Accordingly, charging characteristic of the recycled developer particles is further improved. Thus, better image forming can be performed stably.

In any one of the above-described constructions, it is preferable that the developer particles are a two-component developer including carrier and toner. According to this construction, occurrence of clogging of the developer particles is suppressed. Accordingly, charging characteristic of toner particles including recycled toner particles can be made better.

In the above-described construction, it is preferable that each of the front conveyer and the rear conveyer includes a spiral feeder having a feeder shaft and a spiral fin spirally formed on a periphery of the feeder shaft for conveying developer particles in a predetermined conveyance direction in accordance with an integral rotation of the spiral fin and the feeder shaft. According to this construction, a conveyance mechanism having a simple and inexpensive construction including a feeder shaft and a spiral fin can be established.

In this case, the spiral fin of the rear conveyer has a clockwise spiral direction.

This application is based on patent application No. 2005-342382 filed in Japan, the contents of which are hereby incorporated by references.

As this invention may be embodied in several forms without departing from the spirit of essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within metes and bounds of the claims, or equivalence of such metes and bounds are therefore intended to embraced by the claims.

What is claimed is:

1. A developing device for supplying developer particles to a peripheral surface of an image bearing member comprising:

a housing;

a circulating passage for conveying developer particles while stirring them, the circulating passage being provided in the housing;

a developer supplier for supplying developer particles in the housing;

a developer inlet section for allowing developer particles to come in from the developer supplier, the developer inlet section being formed in an upper portion of the housing;

a conveyance mechanism for conveying developer particles received through the developer inlet section, the conveyance mechanism being provided in the circulating passage; and

a developing roller provided at a position of facing the image bearing member, wherein:

the circulating passage includes a front conveyance passage extending along the developing roller, and a rear conveyance passage extending parallel to the front conveyance passage and passing a position to receive developer particles from the developer inlet section,

the conveyance mechanism includes a front conveyer and a rear conveyer which are rotatable about their respective axes to convey developer particles in specified conveyance directions, the front conveyer being provided in the front conveyance passage and the rear conveyer being provided in the rear conveyance passage, the rear conveyer having a conveyance power reduction portion for reducing the conveyance power locally, and

the developer inlet section includes a first developer inlet opening for allowing developer particles from the developer supplier to come in, and a second developer inlet opening for allowing developer particles recovered from the image bearing member to come in, the first and second developer inlet openings being provided in the circulating passage at locations which are on upstream of the conveyance power reduction portion of the rear conveyer and where developer particles coming from the first developer inlet opening and/or the second developer inlet opening are likely to be upwardly surged due to the rotation of the rear conveyer.

2. A developing device according to claim **1**, wherein the second developer inlet opening is provided in a location which satisfies the following equation:

$$l \leqq \frac{2}{5} \times L$$

wherein l denotes a distance between an upstream end of the rear conveyer in a conveyance direction and a downstream end of the second developer inlet opening, and L denotes a length of the rear conveyer.

3. A developing device according to claim **1**, wherein the second developer inlet opening is provided on upstream of the first developer inlet opening in the circulating passage.

4. A developing device according to claim **1**, wherein the developer particles include carrier particles and toner particles.

5. A developing device according to claim 1, wherein each of the front conveyer and the rear conveyer includes a spiral feeder having a feeder shaft and a spiral fin spirally formed on a periphery of the feeder shaft for conveying developer particles in a predetermined conveyance direction in accordance with an integral rotation of the spiral fin and the feeder shaft.

6. A developing device according to claim 5, wherein the spiral fin of the rear conveyer has a clockwise spiral direction.

7. An image forming apparatus comprising:

a developing device including a conveyance mechanism for conveying a developer; and

a driving mechanism for driving the conveyance mechanism, wherein

the developing device includes:

a housing;

a circulating passage for conveying developer particles while stirring them, the circulating passage being provided in the housing;

a developer supplier for supplying developer particles in the housing;

a developer inlet section for allowing developer particles to come in from the developer supplier, the developer inlet section being formed in an upper portion of the housing;

a conveyance mechanism for conveying developer particles received through the developer inlet section, the conveyance mechanism being provided in the circulating passage; and

a developing roller provided at a position facing an image bearing member, wherein:

the circulating passage includes a front conveyance passage extending along the developing roller, and a rear conveyance passage extending parallel to the front conveyance passage and passing a position to receive developer particles from the developer inlet section,

the conveyance mechanism includes a front conveyer and a rear conveyer which are rotatable about their respective axes to convey developer particles in specified conveyance directions, the front conveyer being provided in the front conveyance passage and the rear conveyer being provided in the rear conveyance passage, the rear conveyer having a conveyance power reduction portion for reducing the conveyance power locally, and

the developer inlet section includes a first developer inlet opening for allowing developer particles from the developer supplier to come in, and a second developer inlet opening for allowing developer particles recovered from the image bearing member to come in, the first and second developer inlet openings being provided in the circulating passage at locations which are on upstream of the conveyance power reduction portion of the rear conveyer and where developer particles coming from the first developer inlet opening and/or the second developer inlet opening are likely to be upwardly surged due to the rotation of the rear conveyer.

8. An image forming apparatus according to claim 7, wherein the second developer inlet opening is provided in a location which satisfies the following equation:

$$l \leqq 2/5 \times L$$

wherein l denotes a distance between an upstream end of the rear conveyer in a conveyance direction and a downstream end of the second developer inlet opening, and L denotes a length of the rear conveyer.

9. An image forming apparatus according to claim 7, wherein the second developer inlet opening is provided on upstream of the first developer inlet opening in the circulating passage.

10. An image forming apparatus according to claim 7, wherein the developer particles include carrier particles and toner particles.

11. An image forming apparatus according to claim 7, wherein each of the front conveyer and the rear conveyer includes a spiral feeder having a feeder shaft and a spiral fin spirally formed on a periphery of the feeder shaft for conveying developer particles in a predetermined conveyance direction in accordance with an integral rotation of the spiral fin and the feeder shaft.

12. An image forming apparatus according to claim 11, wherein the spiral fin of the rear conveyer has a clockwise spiral direction.

* * * * *